IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Koichiro Hayashi et al.	Examiner: Debora Yee
Serial No.: 10/046,770	Art Unit: 1742
Filed: January 17, 2002	Docket: 111698
For: Turbo Component For Turbocharger	Dated: May 17, 2004

Assistant Commissioner for Patents
Washington, DC 20231

DECLARATION OF Michiharu Mogami
UNDER 37 C.F.R. §1.132

Sir:

I, Michiharu Mogami, hereby declares and says that:

(1) I am one of named inventors of the above-identified patent application, U.S. application Serial No. 10/046,770;

(2) I have complete knowledge of the subject matter disclosed in U.S. application Serial No. 10/046,770, filed on January 17, 2002 and have reviewed the applied references, namely US. Patent No. 4,345,943, which was cited in the Office Action dated January 23, 2004;

(3) To clarify that the claimed turbo component for turbocharger is specified from the material disclosed in the above-mentioned prior art reference by demonstrating that the claimed turbo component has a metallic structure in which Cr carbides are dispersed in a ferritic matrix, the following experimentation was performed;

(4) The experiments performed and reported in this Declaration were conducted by me or under my direct supervision

1

or control;

(5) The following reference samples, which are described in Tables 1 to 3 attached, were prepared and evaluated:

Experimentation

An Fe alloy powder (34CRH, produced by Mitsubishi Steel Mfg. Co., Ltd.) of which composition is shown in Table 1, an Fe-20%P powder (20P-Fe, produced by Fukuda Metal Foil Powder Co., Ltd.) of which composition is shown in Table 2, and a graphite powder (SW1651, produced by The Asbury Graphite Mills, Inc.) were prepared and mixed at the rate shown in Table 3. 0.5% by weight of a lubricant (ZNS730, produced by Yokoh Sangyo Co., Ltd) was added to the mixed powder. Using the mixed powder, rings were formed with outside diameter of 30 mm, inside diameter of 15 mm, and height of 10 mm at a forming pressure of 6 ton/cm^2, and a sample was formed by sintering at 1200°C in vacuum for 60 minutes.

Table 1: Fe Alloy Powder (Weight %)

Fe	Cr	Mo	Si	C	P
62.58	31.20	1.92	1.44	2.36	0.50

Table 2: Fe-P Powder (Weight %)

Fe	P
80.0	20.0

Table 3: Mixing Rate (Weight %)

    Fe Alloy Powder   Reminder

    Fe-P Powder   2.50

    Graphite Powder   1.20

Result

Fig. 1 shows a photomicrography of a metal structure of the sample. The photomicrography was obtained through etching using aqua regia, and did not show pearlite in the metal structure. Figs. 2A to 2F show a result of EPMA analysis with respect to the sample. Fig. 2D shows distribution of Fe concentration. In the matrix with a high Fe concentration as shown in Fig. 2D, the C concentration was extremely low as shown in Fig. 2E. Thus, it was shown that the matrix was composed of ferrite. Fig. 2B shows distribution of Cr concentration. In the portion with a high Cr concentration, the C concentration was high as shown in Fig. 2E. Thus, it was shown that the portion with high Cr concentration was Cr carbides. Furthermore, Fig. 2C shows distribution of Mo concentration. In the portion with a high Mo concentration, the C concentration was moderate as shown in Fig. 2E. Thus, it was shown that the portion with high Mo concentration was Mo carbides. According to the above result, it was shown that the metal structure shown in Fig. 1 had a ferritic matrix (brown portion) in which Cr carbides (white portion) and Mo carbides (white portion) were dispersed.

Next, quantitative analysis using EPMA analyzer was performed

to the matrix, and it was confirmed that the matrix was composed of 20% by weight of Cr; 1% by weight of Mo; slight content of C; and the balance of Fe. The composition of the matrix was similar to that of a ferrite-type stainless steel, and it was therefore confirmed that the structure of the matrix was composed of ferrite.

(6) All statements made herein, of his own knowledge, are true, and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made may be punishable by fine or imprisonment or both, under Section 1001 Title 18 of the U.S. code and that such willful false statements may jeopardize the validity of the application or any patent issuing therefrom.

Dated: <u>May 17, 2004</u>

Michiharu Mogami
Michiharu Mogami

Oliff & Berridge
277 South Washington Street, Suite 500
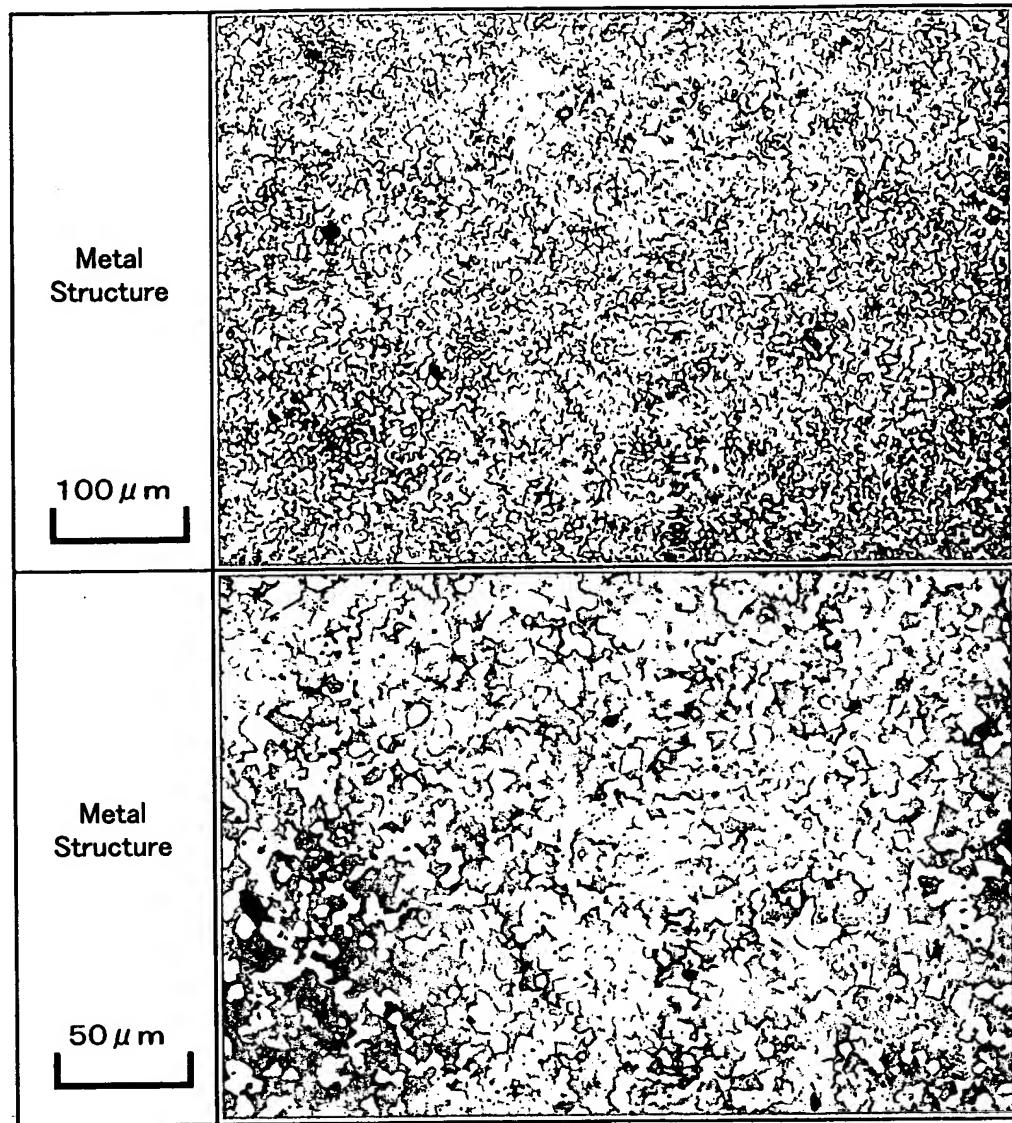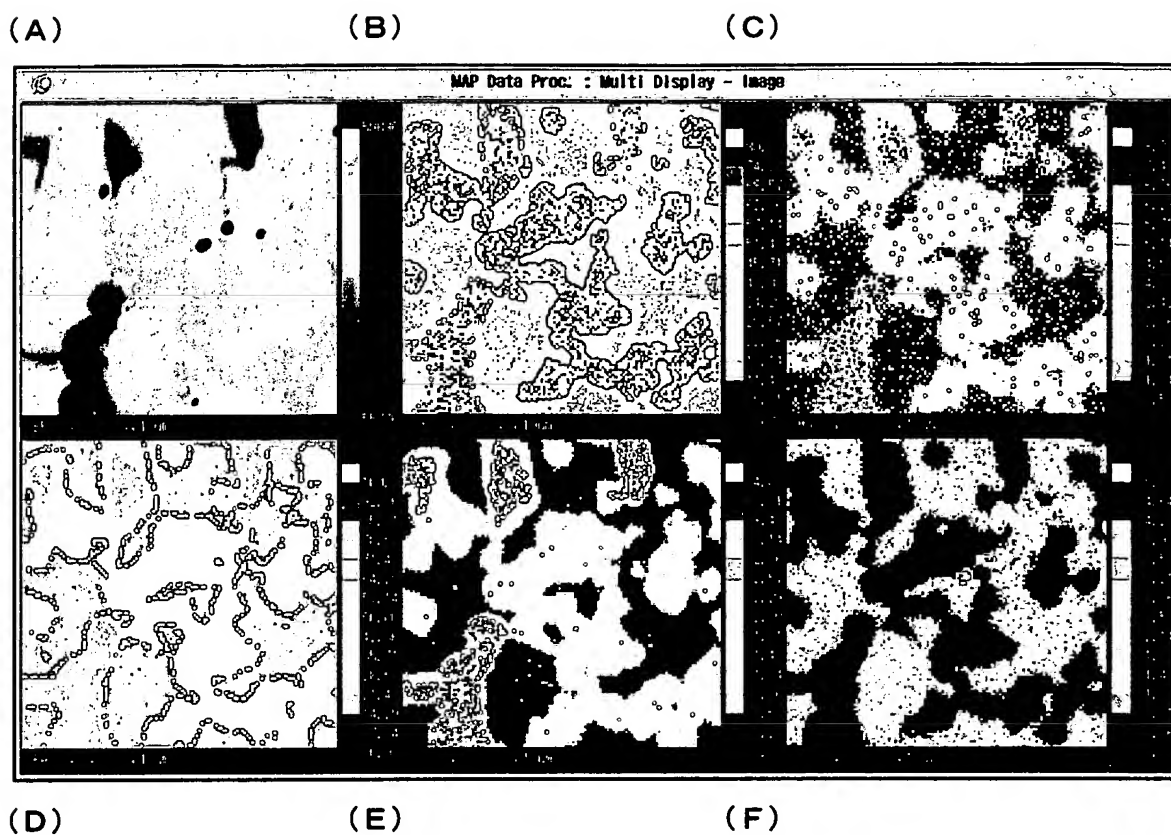Alexandria, Virginia
(703) 836-6400

Fig. 1

Metal
Structure

100 μm

Metal
Structure

50 μm

Fig. 2

(A)   (B)   (C)

(D)   (E)   (F)

Marks'
Standard Handbook for Mechanical Engineers

Revised by a staff of specialists

EUGENE A. AVALLONE   *Editor*

Consulting Engineer; Professor of Mechanical Engineering, Emeritus
The City College of the City University of New York

THEODORE BAUMEISTER III   *Editor*

Retired Consultant, Information Systems Department
E. I. du Pont de Nemours & Co.

Tenth Edition

MARKS' STANDARD HANDBOOK FOR MECHANICAL ENGINEERS

McGraw-Hill

A Division of The McGraw-Hill Companies

although today grain sizes up to 12 are common. Whereas at one time "coarse" grain sizes were 1 to 4, and "fine" grain sizes 5 to 8, these would not serve modern requirements. Most materials in service would be no coarser than 7 or 8, and the ferritic low-alloy high-strength steels routinely approach 12 or smaller. Grain-size relationships in SI units are covered in detail in Designation E112 of ASTM Standards. For further information on grain size, refer to the ASM "Metals Handbook."

EFFECT OF ALLOYING ELEMENTS ON THE PROPERTIES OF STEEL

When relatively large amounts of alloying elements are added to steel, the characteristic behavior of carbon steels is not lost. Most alloy steel is medium- or high-carbon steel to which various elements have been added to modify its properties to an appreciable extent; the alloys as a minimum allow the properties characteristic of the carbon content to be fully realized even in larger sections, and in some cases may provide additional benefits. The percentage of alloy element required for a given purpose ranges from a few hundredths of 1 percent to possibly as high as 5 percent.

When ready for service, these steels will usually contain only two constituents, ferrite and carbide. The only way that an alloying element can affect the properties of the steel is to change the dispersion of carbide in the ferrite, change the properties of the ferrite, or change the characteristics of the carbide. The effect on the distribution of carbide is the most important factor, since in sections amenable to close control of structure, carbon steel is only moderately inferior to alloy steel. However, in large sections where carbon steels will fail to harden throughout the section even on a water quench, the hardenability of the steel can be increased by the addition of any alloying element (except possibly cobalt). The increase in hardenability permits the hardening of a larger section of alloy steel than of plain carbon steel. The quenching operation does not have to be so drastic. Consequently, there is a smaller difference in temperature between the surface and center during quenching, and cracking and warping resulting from sharp temperature gradients in a steel during hardening can be avoided. The elements most effective in increasing the hardenability of steel are manganese, silicon, and chromium, or combinations of small amounts of several elements such as chromium, nickel, and molybdenum in SAE 4340, where the joint effects are greater than alloys acting singly.

Elements such as molybdenum, tungsten, and vanadium are effective in increasing the hardenability when dissolved in the austenite, but not when present in the austenite in the form of carbides. When dissolved in austenite, and thus contained in solution in the resulting martensite, they can modify considerably the rate of coarsening of carbides in tempered martensite. Tempering relieves the internal stresses in the hardened steel in part by precipitating various carbides of iron at fairly low temperature, which coarsen as the tempering temperature is increased. The increasing particle separation results in a loss of hardness and strength accompanied by increased ductility. See Fig. 6.2.6. Alloying elements can cause slower coarsening rates or, in some cases at temperatures from 500 to 600°C, can cause dissolution of cementite and the precipitation of a new set of small, and thus closely spaced, alloy carbides which in some cases can cause the hardness to actually rise again with no loss in toughness or ductility. This is especially important in tool steels. The presence of these stable carbide-forming elements enables higher tempering temperatures to be used without sacrificing strength. This permits these alloy steels to have a greater ductility for a given strength, or, conversely, greater strength for a given ductility, than plain carbon steels.

The third factor which contributes to the strength of alloy steel is the presence of the alloying element in the ferrite. Any element in solid solution in a metal will increase the strength of the metal, so that these elements will materially contribute to the strength of hardened and tempered steels. The elements most effective in strengthening the ferrite are phosphorus, silicon, manganese, nickel, molybdenum, and chromium. Carbon and nitrogen are very strong ferrite strengtheners but generally are not present in interstitial solution in significant amounts, and there

are other processing reasons to actively keep the amount in solution small by adding strong-carbide and/or nitride formers to give interstitial-free (IF) steels.

A final important effect of alloying elements discussed above is their influence on the austenitic grain size. Martensite formed from a fine-grained austenite has considerably greater resistance to shock than when formed from a coarse-grained austenite.

In Table 6.2.2, a summary of the effects of various alloying elements is given. Remember that this table indicates only the trends of the various elements, and the fact that one element has an important influence on one factor does not prevent it from having a completely different influence or another one.

PRINCIPLES OF HEAT TREATMENT OF IRON AND STEEL

When heat-treating a steel for a given part, certain precautions have to be taken to develop optimum mechanical properties in the steel. Some of the major factors that have to be taken into consideration are outlined below.

Heating   The first step in the heat treatment of steel is the heating of the material to above the critical temperature to make it fully austenitic. The heating rate should be sufficiently slow to avoid injury to the material through excessive thermal and transformational stresses. In general, hardened steel should be heated more slowly and uniformly than is necessary for soft stress-free materials. Large sections should not be placed in a hot furnace, the allowable size depending upon the carbon and alloy content. For high-carbon steels, care should be taken in heating sections as small as 50-mm (2-in) diameter, and in medium-carbon steels precautions are required for sizes over 150-mm (6-in) diameter. The maximum temperature selected will be determined by the chemical composition of the steel and its grain-size characteristics. In hypoeutectoid steel, a temperature about 25 to 50°C above the upper critical range is used, and in hypereutectoid steels, a temperature between the lower and the upper critical temperature is generally used to retain enough carbides to keep the austenite grain size small and preserve what is often limited toughness. Quenching temperatures are usually a little closer to the critical temperature for hypoeutectoid steels than to those for normalizing; annealing for softening is carried out just below Ac_1 for steels up to 0.3 percent C and just above for higher-carbon steels. Tables of suggested temperatures can be found in the ASM "Metals Handbook," or a professional heat treater may be consulted.

The time at maximum temperature should be such that a uniform temperature is obtained throughout the cross section of the steel. Care should be taken to avoid undue length of time at temperature, since this will result in undesirable grain growth, scaling, or decarburization of the surface. A practical figure often given for the total time in the hot furnace is 12 min/cm (about ½ h/in) of cross-sectional thickness. When the steel has attained a uniform temperature, the cooling rate must be such as to develop the desired structure; slow cooling rates (furnace or air cooling) to develop the softer pearlitic structures and high cooling rates (quenching) to form the hard martensitic structures. In selecting a quenching medium (see ASM "Metals Handbook"), it is important to select the quenching medium for a particular job on the basis of size, shape, and allowable distortion before choosing the steel composition. It is convenient to classify steels in two groups on the basis of depth of hardening: shallow hardening and deep hardening. Shallow-hardening steels may be defined as those which, in the form of 25-mm- (1-in-) diameter rounds, have, after brine quenching, a completely martensitic shell not deeper than 6.4 mm (¼ in). The shallow-hardening steels are those of low or no alloy content, whereas the deep-hardening steels have a substantial content of those alloying elements that increase penetration of hardening, notably chromium, manganese, and nickel. The high cooling rates required to harden even shallow-hardening steel produce severe distortion and sometimes quench cracking in all but simple, symmetric shapes having a low ratio of length to diameter or thickness. Plain carbon steels cannot be used for complicated shapes where distortion must be avoided. In this case, water quenching must be abandoned and a